THURSDAY, MARCH 7, 1878

REPRESENTATION OF SCIENCE AT THE PARIS EXHIBITION

WE are glad to know that the interest shown in the Loan Collection of Scientific Apparatus at South Kensington and the benefit to the nation at large to be derived from such displays have not been lost upon the organisers of the French part of the forthcoming Exhibition.

Among the most energetic and most enlightened of these organisers we must count M. Bardoux himself, the new Minister of Public Instruction, under whose auspices for the first time a well-developed scientific side will form part of an International Exhibition. Culture will be added to industry. Research will have its place, side by side with the applications of science.

The attempts to give prominence to this side of the exhibition on the part of the French are as remarkable as the complete neglect of everything touching science by our own Commission. For them apparently science does not exist, except the science that pays, in the shape of large engines and looms, fine stuffs, machine-made jewellery, and the like. England will have its Burlington Arcade, but not its Burlington House. We give the Commission credit for having "worked" the commercial world well; we only complain that the possibility of there being anything worth exhibiting from the scientific point of view never seems to have occurred to them.

The antithesis we have drawn between the Burlington Arcade and Burlington House well represents the great point of the forthcoming Exhibition. There will be a gigantic shop on the Champ de Mars, there will be a gigantic temple devoted to the pure sciences and to pure art in the Trocadero. The river will separate the source from the application; instruction in science and art from commerce and industry.

Hence it is that M. Bardoux, having already organised on a large scale the representation of the fine arts and public instruction, is now organising what is to be called the "scientific display." This part of the work, important though it be, will be rendered very simple to the Minister, as the matter will be left almost entirely in the hands of the men of science themselves, including, of course, those men of science who direct important branches of the public service as well as individual investigators.

Thus each Government department will show the way in which its scientific work is done. The three new Government observatories in Paris will exhibit either results or methods. There will be a complete collection illustrating the various scientific missions which France has undertaken during the present century, and all the publications, scientific, historic, and artistic, which have been published by the state will be there for all the world to see.

Not only, therefore, will there be a true Loan Collection of Scientific Apparatus, but the example set by the South Kensington Conferences will also be followed. The enormous building in the Trocadero contains a lecture theatre capable of holding upwards of 4,000 people. This will be used for lectures in scientific and kindred subjects, for which arrangements are now being made. It is impossible that the Trocadero buildings can be ready by May 1, so there will be ample time for these arrangements and for the others, to which we may briefly allude.

The French Association for the Advancement of Science will conduct a large number of scientific experiments on a great scale, and a large number of exhibitors will take advantage of the meeting of that association to exhibit experiments relating to their special pursuits.

Every facility will also be given to scientific societies for summoning to a special congress those prosecuting the same line of research. The number of these useful assemblies is increasing daily. It would occupy too much space to give a list of all the societies which will hold such meetings, but many circulars illustrating the development of this sectional movement have already been printed.

Lecture-rooms will be furnished *gratis*, lectures will be advertised on a large scale, and, as far as possible, Government apparatus will be at the disposal of inventors for conducting the experiments required to illustrate their lectures. What has been done at the provisional Ethnographical Museum, to which we have already referred, may be considered as a fair specimen of what will be done on a larger scale at the Trocadero Palace and other suitable buildings.

It may be said that nothing will be spared to make the Exhibition useful to science and intelligible in its scientific aspects for the largest number of people.

Surely England might have been able to contribute something of interest to this most interesting side of the Exhibition? We surely must, after all, be merely a nation of shopkeepers seeing that our Royal Commissioners have doubted our capabilities in any other direction!

METROLOGY

Inductive Metrology; or, The Recovery of Ancient Measures from the Monuments. By W. M. Flinders Petrie. (London: Saunders, 1877.)

THIS work has a somewhat ambitious title, but it may fairly claim to be written upon a scientific basis, and it bears evidence of much study and laborious research. It is an attempt to carry out generally the method originated by Sir Isaac Newton, in his well-known Dissertation on Cubits, of determining the length of the ancient Egyptian cubit from some of the measured dimensions of the great pyramid. By a similar process the author has endeavoured to determine the ancient standards of linear measure in various countries from the measurements of remaining monuments. No allusions are made to weights and volumes, but only to linear quantities, as these alone are shown by the architectural remains.

In accordance with Whewell's definition of "induction," Mr. Petrie says that "inductive metrology ascertains the 'general truths' of the units of measure in use from the 'particular facts' of those multiples of measures which ancient remains preserve to us." He assumes that in the construction of all such works, if a measure existed, it would be used, and that whole numbers would be used in preference to fractions and round numbers in preference to uneven ones, merely for convenience in the work. We know this to have been the case with regard to the various dimensions of the tabernacle constructed by Moses, of Solomon's Temple, and the later temple as described by Ezekiel, The length of the Royal Egyptian Cubit was determined by Sir Isaac Newton, from Greaves's measurements in the great pyramid, to have been between 20·62 and 20·78 English inches. Amongst these measurements the so-called King's Chamber was found to be 20 of such cubits in length, and 10 in breadth. The passages were 2 cubits broad. The principal gallery was 4 cubits broad, with a middle way of polished marble 2 cubits broad, and a raised bench on each side 1 cubit broad and 1 cubit high. In Newton's time, no direct evidence of the true length of the ancient Egyptian cubit had been brought to light. We now know from several ancient standard cubit rods since discovered, that the mean length of the royal Egyptian cubit was equal to 20·67 English inches. In this essay Mr. Petrie states that all the deduced units of measure were in every instance found in a similar way independently of any known standard, and have not been obtained by trying whether the measures would fit any known unit. As to standards of measure, they are only employed by the author to subject assumptions to proof, where such can be obtained.

The least number of measurements that suffice to give a unit with tolerable certainty is assumed to be three. Long lengths were found of little value in obtaining the unit, and moderately short lengths from about 2 to 20 feet are stated to be the best. After showing the several modes of ascertaining as nearly as may be the unit of measure from a given number of actual measurements, that is to say, the ratio between them, the process adopted has been to group together those units of any one country and age that seemed to be identical, or derived from and related to one another, and thence to deduce the mean unit. In every case the probable error has been computed and stated. This probable error is assumed to arise from original errors in planning and executing the work, and not in the more recent measurements, as with reasonable caution such errors may be tolerably avoided.

The extent of the work undertaken by the author may be judged of from the statement that more than 600 buildings and other remains have been examined and their constructors' units deduced from the mean results of over 4,000 measurements. A considerable number of them were made by the author, many being of objects in the British Museum. To insure correctness the English measure used by him was verified as to its accuracy at the Standards' Office.

The first series of groups relate to Egyptian architectural remains, generally from the fourth dynasty to the Roman period. The deduced units of the measurements of 101 monuments are stated in English inches and decimal parts of an inch, and the number of independent lengths from which each such unit was obtained is also specified. The deduced units of one of these groups, consisting of twenty-eight different monuments vary only from 20·42 to 20·84 inches, the mean being 20·64, thus agreeing very nearly with the ascertained length of the royal cubit = 20·67 inches. From the remaining monuments the author deduces other units several of which are multiples of the digit, the twenty-eighth part of the royal cubit. The common cubit, or cubit of a man, equal to 18·24 inches, has not yet been found inductively from remaining monuments.

The next series of monuments examined are those of Babylonia and Assyria, Persia and Syria. These countries are classed together as being intermixed in the style of their art and the nature of their architectural remains. The results of the measurements of 102 monuments are given, with various deduced units of measure. The Persian monuments are chiefly those of Persepolis. It may be more interesting to refer to the Syrian monuments as they include those of Judæa and Palestine, and of Moab. As an instance, the mean unit of 25·01 inches (varying from 24·57 to 25·55 inches) is found from six monuments, four of which are at Jerusalem. This is taken to be the mean length of the sacred Jewish cubit. It is to be observed that in his "Dissertation on Cubits," Sir Isaac Newton arrived at the conclusion that the length of this cubit was 24·83 inches. It is now generally considered to have been a little more than 25 inches, and it is supposed to have been the cubit measure taken from Chaldæa by the ancestors of the Jews, and to have continued in use by their posterity in Egypt and Palestine.

The countries that follow are Asia Minor and Greece. The first of these affords eleven different units from eighty-four measured monuments. Eight of these units are known to have been used by nations that ruled there, and the other three are connected with the units of adjacent countries. From Greece and its colony Sicily the results of the measurements of forty-nine objects are given, including Pelasgic and later monuments.

Italy, Africa, and Sardinia are next classed together. The results of the measurements of seventy-seven monuments are shown under the head of Italy, including Roman remains in Britain, Africa, and other countries probably constructed with Italian units of measure.

The mediæval remains in Ireland and England conclude the several classed groups of monuments measured. The measurements of twenty-nine round towers and churches connected with them in Ireland give two deduced units. Out of eighty-one measured old English remains the inch and foot were found to be the units in sixteen cases only, the mean inch unit being equal to 0·9998 of our present standard inch, showing that on the average the inch measure has not varied appreciably for centuries. Several other units of other countries are deduced from the remaining monuments.

The last series of measurements are those of rude stone remains and earthworks in various countries. At first sight it does not appear possible that such objects should lead to units of measure being derived from them; but the results show, in the author's opinion, that the more regularly constructed remains were made by a measure-using people.

After mentioning the results of measurements partly of the dimensions and partly of the relative positions of various ancient stone remains and earthworks in this country and in France, the results of about seventy measurements of the dimensions of ancient North American earthworks are stated to lead to a unit varying from 12·50 to 12·72 inches, with a mean of 12·6 inches, divided duodecimally. The mean unit of twelve Mexican measurements was 10·65 inches.

The author claims, as the chief results of his inductive examination, to have determined from the monuments the true values of the Sacred Hebrew or Royal Persian cubit, the Royal Egyptian cubit, the Egyptian digit, the Assyrian cubit, the ancient Greek foot, the Olympic foot, the Drusian foot, the Plinian foot, and the Pythic foot, together with the probable errors of these determinations.

He claims also to have found that the principal standard units of length were in more extended use than was previously known, and to have indicated the countries in which they were used. And also that he has brought to light many other units of length of which the knowledge had been previously lost.

It is not probable, however, that all persons who have given mature consideration to the contents of the work will concur in the stated results or be altogether satisfied with some of the mean units obtained. In every case a unit deduced from the actual measurements is stated, and not the measurements themselves. But a large proportion of these deduced units are not whole numbers of the mean unit obtained from them. Thus, taking one of the instances most favourable to the author's views, out of twenty-eight Egyptian monuments, from which the mean length of the royal Egyptian cubit is obtained, twelve only of the deduced units are whole numbers, the others being various fractions of the mean unit, and many of them, such as $\frac{1}{3}$, $\frac{1}{6}$, $\frac{1}{8}$, $\frac{1}{10}$, $\frac{1}{12}$, $\frac{2}{3}$, $\frac{5}{8}$, $\frac{1}{30}$, $\frac{4}{30}$ are fractions not marked upon any of the extant standard cubit rods, which are divided only into seven palms and twenty-eight digits.

The essay will be read with much interest and advantage by those persons who have given their attention to metrological science. It appears to be a valuable contribution to historical and ethnological literature, and to be a ground-work for further researches on the subject.

WOLF'S HISTORY OF ASTRONOMY[1]

II.

Geschichte der Astronomie. Von Rudolf Wolf. (München : R. Oldenbourg, 1877.)

IN our former notice of this valuable addition to astronomical literature (NATURE, vol. xvii. p. 259) reference was made to the great amount of information which the author has compressed within a moderate space in the third and last section of his work which treats of "the newer astronomy." We propose here to take a brief survey of the principal contents of this portion of the volume to assist the reader's appreciation of the work.

The third section is subdivided into four chapters—9—12. The first commences, as before stated, with Sir Isaac Newton's discovery of the principle of universal gravitation, the publication of the "Principia," and the first application of the new theory to the orbits of comets by Halley, whose meritorious connection with the publication of Newton's immortal work is well known. This is followed by some account of the foundation of the Observatories of Greenwich and Paris, and soon afterwards of those of Berlin and Copenhagen, whereby so great an impetus was given to practical astronomy; of Richer's expedition to Cayenne for the determination of the solar parallax, from corresponding observations of the planet Mars, and the first ideas as to the applicability of transits of Venus for the solution of the same problem. The labours of the earlier workers in the Newtonian theory—of Bernoulli, Euler, Clairault, and others, are particularised; also Bradley's great discoveries of the aberration of light and the nutation of the earth's axis, together with his work in the field of observation, with the similar work of Tobias Mayer and Lacaille. Further on the same chapter treats of the labours of Lagrange, Laplace, Gauss, and others in theory, and of Herschel, Piazzi, Bessel, Struve, and others, in the practice of astronomy. We have some account of the "Theoria Motus," the "Fundamenta Astronomiæ," amongst classical works, and of progress made in the solar, lunar, and planetary theories, and formation of tables and ephemerides. Amongst the remaining varied contents of this chapter there are notices of the discovery of Neptune, stellar parallax, the connection between solar spots and the earth's magnetism, the application of photography to astronomical purposes, and the introduction of the spectroscope.

Chapter 10 is devoted to astronomical instruments and their uses, after some remarks upon methods of calculation introduced in modern practice. There are brief notices of instruments in their various forms, from the complicated heliometer to the simpler appliances in the hands of observers, with descriptions of many of the more important purposes for which they have been brought into use. The chapter concludes with a reference to Lacaille's memorable expedition to the Cape of Good Hope and the expeditions undertaken on occasion of the transits of Venus in 1761 and 1769.

Chapter 11, on "The Structure of the Heavens," is as varied in its contents, amongst which we may note: The periodicity of sun-spots, and the new views upon the physical constitution of the sun; the ring of small planets; the zodiacal light; the meteor-streams and their connection with comets; the physical condition of comets; the distribution of the stars; the Milky Way; solar motion in space; variable and double stars, and binary systems; stellar spectra, star clusters, and nebulæ.

In Chapter 12 we have an account of the principal modern literature, periodical and otherwise, bearing upon astronomical science in its various branches. There are notices of the works of Weidler, Lalande, Bailly, Montucla, Delambre, Littrow, Madler, and others, and of such works as the *Acta Eruditorum*, the *Monatliche Correspondenz* and the *Astronomische Nachrichten.*

It should be understood that the one chief advantage which the student is likely to derive from Prof. Rudolf Wolf's "History of Astronomy" will be a knowledge of the authors, methods, &c., with which it may be necessary for him to become acquainted in turning his attention to any particular department of astronomy, an advantage that may not be immediately apparent from the title of the work. Prof. Wolf does not enter into any amount of detail, nor indeed would it have been practicable within the limits of this volume. But as affording in comparatively brief space an accurate idea of the gradual progress and actual state of astronomical science and a valuable guide to any one entering upon its study, this book may be confidently recommended. J. R. HIND

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[1] Continued from p. 259.